キラピカマップ THE LIGHT MAP

Light is as indispensable to life as air. It not only brightly illuminates our rooms but is also widely used for power generation and manufacturing using its energy and for a variety of things that make life comfortable.

This KIRAPIKA Map introduces in an easy-to-understand manner how characteristics and phenomena of light are used in daily life.

◂ Kirapi

Natural light and light created by humans

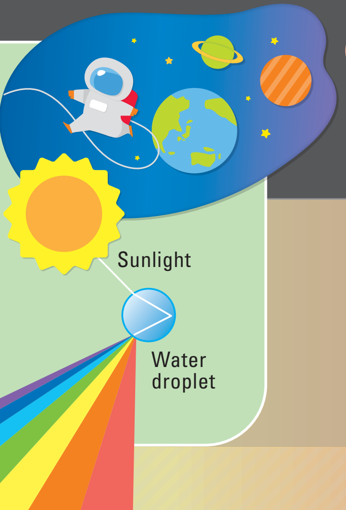
Through the ages, natural light has shined down on Earth from the Sun, the Moon, and stars. Bacteria that appeared about 2.5 billion years ago generated oxygen using energy from sunlight and gave birth to a variety of organisms. Since the birth of humanity, we have devised ways of creating light ourselves in order to live more comfortable and convenient lives. First, we created light by burning things with fire, and later we created easier to use and more powerful light with electric bulbs, LEDs, and other things using electricity. Light is used in a wide variety of settings according to its characteristics.

Types of light

The color of light can be expressed with words like red, blue, and green. However, since there are many more types of color, wavelength numbers can be used to distinguish colors in detail. Wavelength is expressed in micrometer (μm) or nanometer (nm) units. There is also light we cannot see but is very useful in our lives. Light with wavelengths longer than red light is called infrared light. Light with wavelengths shorter than violet light is called ultraviolet light, and light with wavelengths shorter than this is called an X-ray.

How do rainbows form?

Rainbows after rain appear to contain seven colors because of the refraction and reflection of sunlight in small water droplets floating in the air, which causes the light to travel in different directions according to color. This is called a spectrum



Let's play with light in the KIRAPIKA LAB

The Photon Valley Center holds events in which children can learn while playing with experiments using light!

Experiment in the KIRAPIKA LAB!

We saw rainbows formed from sunlight with handmade spectroscopes!

Hamamatsu-related pioneers of photonics technologies

Prof. Kenjiro Takayanagi

Father of television

Born in Hamamatsu in 1899, Prof. Takayanagi conducted research on mechanisms and technologies for displaying images from distant places, called the "wireless far-sight method" (television). In 1926, he succeeded in displaying the character イ using a method involving photography and cathode ray tubes. Although his research was interrupted by World War II, he subsequently continued it and completed his television receiver (current television).

Prof. Masatoshi Koshiba

Detection of neutrinos

Born in Toyohashi in 1926, Prof. Koshiba built the Kamiokande detector at the site of Kamioka Mine in Gifu Prefecture to observe elementary particles called neutrinos. The system detects faint light generated when neutrinos collide with electrons in water, and it successfully detected neutrinos emitted by a supernova explosion outside our solar system for the first time in the world. Prof. Koshiba was awarded the Nobel Prize in Physics in 2002 for this achievement.

Prof. Hiroshi Amano

Development of blue light-emitting diodes (LEDs)

Born in Hamamatsu in 1960, Prof. Amano developed blue LEDs and was awarded the Nobel Prize in Physics in 2014. LEDs are semiconductors with properties that cause them to glow when current flows through them, and the development of these blue LEDs led to the birth of the LED lighting widely used around the world. Because of its long life span and low power consumption, environmental friendliness is a feature of LED lighting.

Wavelength

◂ Short wavelength

0.01 nm — X-rays (invisible light)

"X" rays (wavelengths of 0.01-10 nm), the name originally given to a mysterious "unknown" light, easily pass through soft objects but have difficulty passing through hard objects.

X-ray exams in hospitals

X-rays pass through soft skin tissue and make it possible to observe things like the shapes of hard bone tissue and the status of the lungs in the body.

Baggage inspection at airports

X-rays make it possible to check the contents of baggage and for dangerous substances and other things that are not visible from the outside.

Quality inspections at food plants

X-rays make it possible to find metals and plastics mixed in food. In addition, they are also used to check packed foods for shape defects and quantity.

Defective product found!

10 nm — Ultraviolet light (invisible light)

Invisible light with a wavelength shorter than violet light is called ultraviolet light (wavelengths of 10-380 nm), which means beyond violet light.

Black light

Special invisible inks become visible when illuminated with ultraviolet light from a black light. This is used for hidden markings to prevent the counterfeiting of paper money and credit cards.

Ultraviolet sterilization

Ultraviolet light suppresses the proliferation potential of microorganisms and kills them. Because it only involves the application of light, it is widely used for water, food, pharmaceutical products, and other things.

Sunscreen creams

Sunburns are caused by the ultraviolet light contained in sunlight. Sunscreen creams applied to the skin protect it by absorbing or reflecting ultraviolet light.

Elimination of harmful substances with photocatalysts

Oxidation is promoted around photocatalysts when they are exposed to ultraviolet light. This breaks down harmful substances, odors, and other contaminants.

Insect control

Taking advantage of the behavior of insects, which tend to gather in ultraviolet light, it is possible to gather insects with ultraviolet light or to prevent them from gathering with light that does not contain ultraviolet light, such as that from LEDs.

Eyes of honeybees

The light that honeybees can see spans from ultraviolet to yellow light. They can see flower patterns that are invisible to humans, and this makes it possible for them to accurately determine the locations of honey and pollen.

Photos from Flower signals sent to insects: The world seen through ultraviolet light by Fumio Yokozawa, 1995.

The patterns seen are different!?

380 nm — Visible light (light visible to human eyes) — 780 nm

Light our eyes can see actually contains many colors, such as violet, indigo blue, blue, green, yellow, orange, and red. Such light is called visible light (wavelengths of about 380-780 nm).

Violet | Indigo blue | Blue | Green | Yellow | Orange | Red

Objects cannot be seen without light

In space, bands of light are not visible because there is no air!

When light from the sun, lighting, or other sources hits objects, the brain recognizes the reflection and scattering of the light, and we are able to see the colors and shapes of the objects. In a pitch-black room, we cannot see colors, let alone recognize the shapes of objects. This is because there is no light reflecting from objects and entering our eyes. If we turn a flashlight on in a dark room, we can see a band of light. This is because the light emitted from the flashlight reflects off of invisible particles and dust in the air.

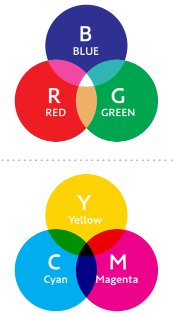
How we see colors

Three primary colors of light (colors of light that are the basis for creating various colors of light)

Other colors of light can be created by mixing three colors of light: red, green, and blue (RGB). Light is white when all three colors are mixed together. Light is yellow when just red and green are mixed together. TVs and computer monitors use these principles to create a multitude of colors.

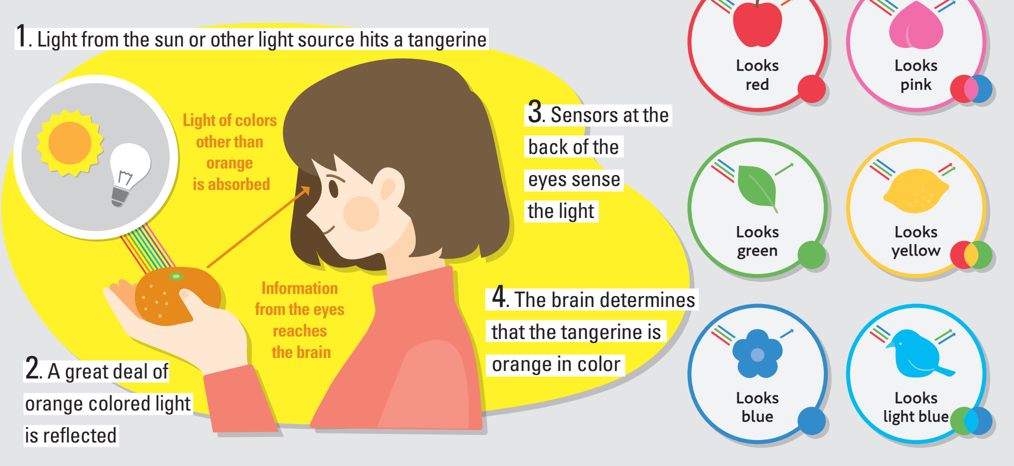
Three primary colors (colors of ink that are the basis for creating various colors)

Other colors of ink can be made by mixing three colors of ink (pigments): cyan, magenta, and yellow (CMY). Ink is "black" when all three colors are mixed evenly together. Ink is green when yellow and cyan are mixed together. Books, flyers, and this KIRAPIKA Map are printed using these principles.



How do we see the colors of objects? (reflection and absorption)

When we look at objects, we see the light reflected from them that enters our eyes. Taking the orange color of a tangerine as an example, a great deal of the orange colored light from the sun or other light sources is reflected, and the rest of the light is absorbed by the tangerine. The reflected light that reaches our eyes is seen as a color.



1. Light from the sun or other light source hits a tangerine
Light of colors other than orange is absorbed
2. A great deal of orange colored light is reflected
Information from the eyes reaches the brain
3. Sensors at the back of the eyes sense the light
4. The brain determines that the tangerine is orange in color
Looks red
Looks pink
Looks green
Looks yellow
Looks blue
Looks light blue

Relationships between light and objects

When light hits an object, it is affected in a variety of ways. These effects on the light are what allow us to see the color and shape of the object.

❶ Reflection of light

The phenomenon in which light bounces off the surface when it hits an object is called reflection. Light that hits a flat object, like a mirror, is reflected at the same angle.

❷ Refraction of light

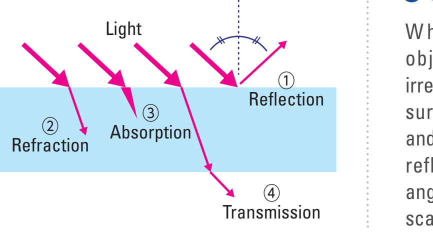
Some light is reflected, and the rest of it enters the object and changes direction. The phenomenon in which light bends at the boundary of an object at that time is called refraction.

❸ Absorption of light

The phenomenon in which light is absorbed into an object is called absorption, and the absorbed light is converted into heat.

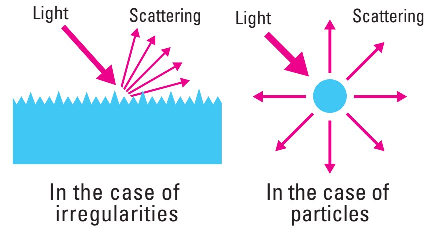
❹ Transmission of light

Light that is not absorbed by an object passes through the object. This phenomenon is called transmission.



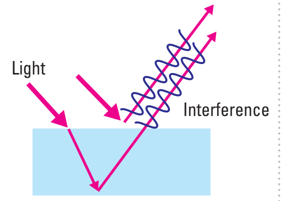
❺ Scattering of light

When light hits objects with small irregularities on their surfaces, particles, and other things, it is reflected at various angles. This is called scattering.



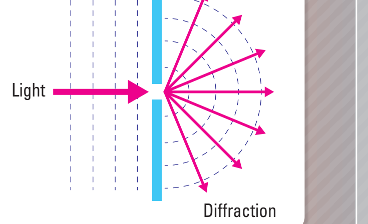
❻ Interference of light

Since light has the properties of waves, light waves are strengthened or cancelled out when they collide with each other in a phenomenon called interference.



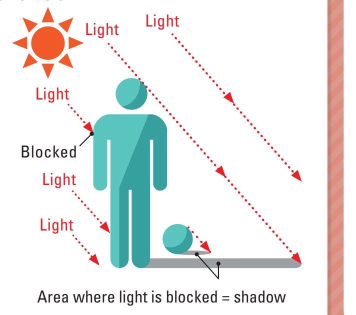
❼ Diffraction of light

The phenomenon in which light spreads after it hits a small object and passes around it or passes through a narrow hole is called diffraction



How are shadows generated?

Since traveling in a straight line is a characteristic of light, it will hit any obstacles in its path, generating shadows that look black (dark) because no light reaches there. If the obstacles move, the shadows also move, and this is why our shadows follow us when we run in the sun.



TVs use three primary colors of light to create 16.7 million colors. When the surface of the screen is magnified, we can see that it is made up of three types of small rectangles that glow red, green, and blue.

Experiment in the KIRAPIKA LAB!

What color will the light be if three colors of light are mixed together?

Why isn't light in bathrooms too bright!?

In bathrooms, light hits particles of water vapor and is diffracted, so it is not too bright.

Infrared light (invisible light) — 1000 μm

Invisible light with wavelengths longer than red light is called infrared light (wavelengths of about 780 nm-1000 μm), which means below red light.

Long wavelengths ▸

Monitoring cameras

Infrared light is emitted and detected by the camera!

Since the wavelengths used are invisible, cameras go unnoticed by people even in the dark. In addition to being used for crime prevention, they are also used to observe wild animals.

Thermography and clinical thermometers

By detecting the infrared light generated based on the temperature of the body, it is possible to measure the temperature without touching the body and to observe the distribution of body temperature.

Remote controls

The signals sent from remote controls to TVs use invisible infrared light that is safe for the eyes.

Motion sensors

A human body with a higher temperature than its surroundings emits more infrared light than its surroundings. This is used for human body detection, such as in crime prevention sensors for detecting the entry of thieves and motion sensors for air conditioners.

Stone-roasted sweet potato

The infrared light emitted by heated pebbles, which heats even the interiors of sweet potatoes, makes it possible to cook delicious roasted sweet potatoes.

Infrared heaters

Infrared light is absorbed by the surfaces of the body and becomes heat, and it warms the body up from within via the circulation of blood, etc.

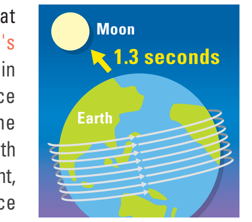
Brix meters

Sweetness can be determined!

Infrared light specifically associated with sweetness can be used to measure sweetness without damaging fruit.

Nature of light

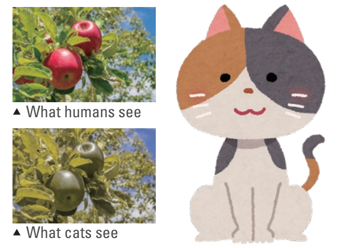
The speed of light is about 300,000 km per second. That speed makes it possible for light to travel around Earth's equator 7.5 times per second. The distance light travels in one year at the speed of light is called a light year. Since the stars shining in the night sky are very far away, the distances to them are represented in light years. The length of one meter is also determined based on the speed of light, and it has been established that one meter = the distance that light travels in a vacuum in 1/299,792,458 of a second.



▲ Light takes 1.3 seconds to reach the moon!

Eyes of animals

The human eye has three types of sensors that sense color and respond to red, green, and blue light well, and it recognizes many colors based on the balance of these colors. Birds and insects live in more colorful worlds than humans, as they have four types of sensors: for red, green, blue, and ultraviolet light. On the other hand, many animals have eyes with sensors that sense only two colors, red and blue, so they cannot distinguish between colors as finely as humans. In other words, living things see different worlds of colors because the sensors for sensing color vary among them.

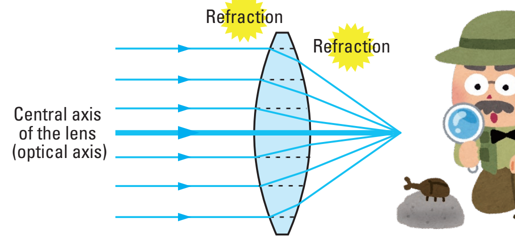


▲ What humans see

▲ What cats see

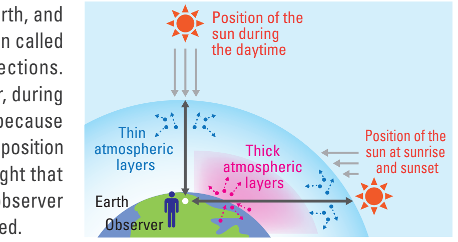
Light travels in different directions after passing through a lens (refraction)

Light bends when it enters and exits glass, and this changes the direction in which it travels. This phenomenon is called refraction. Because the lens of a magnifying glass that is thicker in the middle bends light toward the center, it can make things look bigger when we look through it and can concentrate light at one point to create intense light.



Why does the color of the sky change? (scattering)

There are layers of air, called the atmosphere, around the earth, and when light hits small molecule particles in them, a phenomenon called scattering occurs in which light is scattered in various directions. When the position of the sun is high, as seen by the observer, during the daytime, the entire sky becomes a screen and looks blue because the blue light is scattered easily. On the other hand, when the position of the sun is low early in the morning or evening, only red light that passes through the thick layers of the atmosphere near the observer arrives and is scattered, and the sky in the east or west looks red.

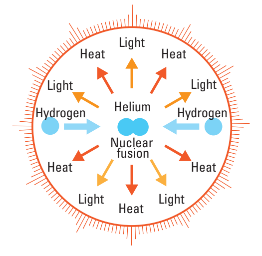


Why does the moon shine?

The moon shines brightly in the sky, but it does not emit light itself. It looks bright because it reflects light from the sun like a mirror.

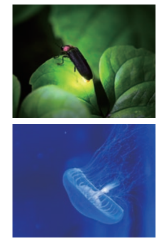
Why does the sun shine?

Nuclear fusion at the core of the sun generates extremely high amounts of energy in the form of heat and light. This reaches Earth in the form of sunlight.



Light emitted by living organisms

In the natural world, light is also produced by chemical reactions in the bodies of living organisms, such as the light emitted by fireflies and jellyfish. Living organisms are thought to emit light to attract prey for food, to scare enemies, to communicate with mates, and for other reasons.



Secret of the mystery of auroras

Auroras are the result of the effects of solar wind, electrons and protons ejected by explosions on the surface of the sun that surge toward Earth like wind. This solar wind gravitates toward Earth's magnet field and stimulates the emission of light from oxygen and nitrogen in the sky above the north and south poles. This is an aurora that shines like a curtain in the sky.

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